Wilder (B. G.)

Misc

THE TRIANGLE SPIDER.

By Prof. BURT G. WILDER,
OF THE CORNELL UNIVERSITY.

Reprinted from The Popular Science Monthly, April, 1875.

STROLLING through the woods near Ithaca, New York, one October afternoon, I saw, upon a leafless hemlock-branch, what looked like a piece of the net of some geometrical spider. Still, there was a regularity in this triangular net which did not accord with the idea of its being a fragment. A closer examination showed that its form and structure were perfect and unbroken; and moreover that, instead of hanging loosely from the twigs, it was *upon the stretch*, as if constantly drawn by a power at one or the other end (Fig. 1).

On touching the net to determine its degree of tension, what was my amazement to see it suddenly loosened with a snap, as if let go at one end! Nor was my wonder diminished when, a moment afterward, the the net slowly regained its original condition, by a steady pulling upon a short line connected with the apex. And now I saw the puller—a little dull-colored spider, about one-eighth of an inch long—hanging from the under side of the apex-line, and hauling it in, not "hand over hand," as at first appeared, and as one would suppose by analogy with sailors' operations, but "foot over foot;" in short, with its *hinder legs* moved alternately so as to gradually take in that part of the line which intervened between its body and the twig to which it was attached.

When this line was all taken in, the spider was close against the twig, and its legs were drawn together, so that the whole formed a compact brown mass about the size and shape of a raisin-seed, and differing so little in appearance from the projections of the dried hemlock-twigs among which the net was built, that I felt in part excused for not having noticed the little creature before.

So much for an introduction to a spider which was then new to me, and probably is still unknown to most of my readers. In some respects its habits are unlike those of all our other spiders; and I will here relate what I have learned during five seasons, in the hope that

others may have the fortune to clear up the points in its economy as yet undiscovered.

Our spider is thought by high authorities to be a species of the genus called *Hyptiotes* by Walcknaer, and afterward and more commonly *Mithras;* but the former name has priority. Of this genus two European species have been described; one of which, *H. paradoxus*, has lately been found in England, and described by the veteran arachnologist, Mr. Blackwall. Our American species seems to be that referred to by Hentz as the *Cyllopodia cavata*,[1] but his description is so brief,

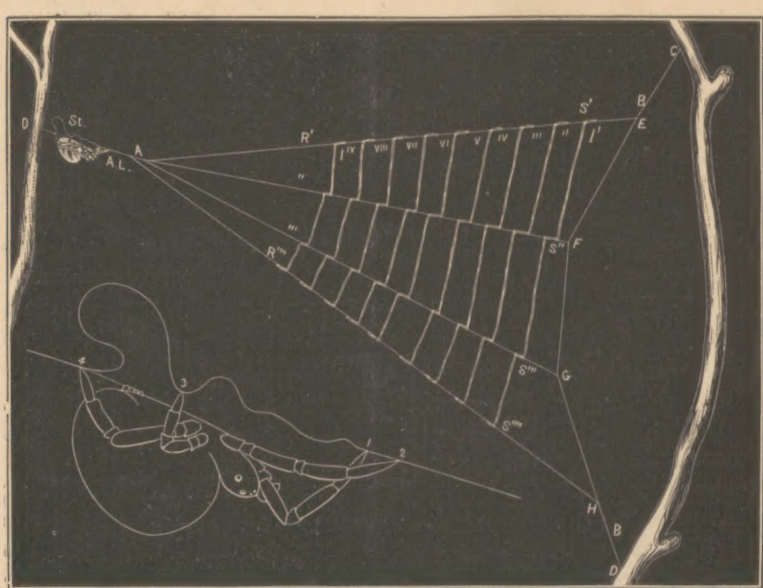

Fig. 1.—Net of the "Triangle Spider," about one-half the usual length. The spider, however, is shown of the natural size.

B B, the base-line attached, at *C* and *D*, to a hemlock-branch; *E F G*, points of attachment to the base-line of the three radii, R' to R'''', which converge at *A*, the apex of the net; I' to I^{IX}, nine transverse or interradial double lines; S' to S'''', attachments of the first interradial upon the radii; *A L*, apex-line; *O*, origin of the apex-line from a second branch; *Sl.*, loop of the apex-line or "slack," between the front and hinder feet of the spider: this is better shown in the lower enlarged figure.

and in some respects erroneous (giving only six eyes, whereas there are eight), that we shall probably avoid confusion by calling this a new species (*H. Americanus*).

Having now identified the spider sufficiently for our present purpose, we have to inquire:

1. Which is *the spider*, the male or the female?
2. How is the net made?
3. How is the net used in taking prey?
4. What are the relations between this and other spiders?

1. Which is the Spider? As is often, although by no means

[1] *Boston Journal of Natural History*, 1847, vol. v., p. 466, plate xxx., Fig. 3.

universally, the case among spiders, the female is the head of the family. In fact, so scarce are the males that for three years I never found one among more than a hundred specimens. This, however, is not absolute proof of their much smaller number, for they are less in size and darker in color, and, like the males of the "silk-spider of

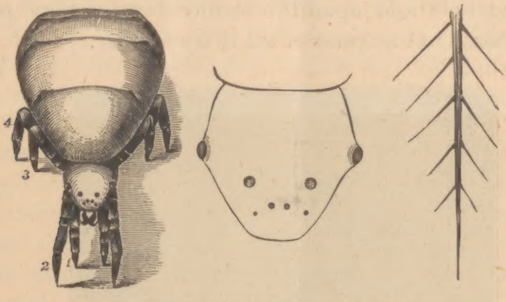

FIG. 2.—At the left a female *Hyptiotes*, enlarged about eight diameters. The legs are marked 1, 2, 3, 4, in order from before backward. In the central figure is shown the front part of the spider (the cephalo-thorax), still more enlarged, so as to display the eight eyes arranged so as to form two crescents with their convexities opposed thus ⌣⌢. At the right is a greatly-magnified feathered bristle from the upper surface of the cephalo-thorax.

South Carolina" (*Nephila plumipes*), they make no nets, but seem to get a precarious living by hanging on to that of some female. Their masculine nature is seen in the structure of the "palp" or feeler, which, instead of tapering to a blunt point, as in the female, is greatly enlarged, its last segment presenting the remarkably complex structure seen in Fig. 3.[1]

FIG. 3.—Terminal joints of the palp or feeler of the male *Hyptiotes Americanus*, much enlarged. (Drawn from Nature, by Prof. W. S. Barnard.)

[1] These modified palpi are undoubtedly connected with the reproductive function. Others besides myself have seen them (with other and larger species) applied to the vulva of the female during an evident copulation; but all do not assent to the generally-received opinion, that they are merely intromittent organs, which have first received the spermatic fluid from the testicular orifice upon the ventral surface of the abdomen. (For a note upon the subject, by Mr. Gedge, with references, *see Journal of Anatomy and Physiology*, 1867, vol. i., p. 371.)

It is possible that, as with the *Nephila plumipes*, the *young* males of *Hyptiotes* construct nets, but of this I can say nothing; for as yet I have never seen what I was certain were the eggs or the very young. Near Ithaca I have found the partly-grown spiders, during the latter part of July, and the adults are all gone before the close of November. Certain little cocoons (Fig. 4), which are quite abundant in the same localities and upon the hemlock-twigs, may prove to be made by this spider, but at present all is conjecture.

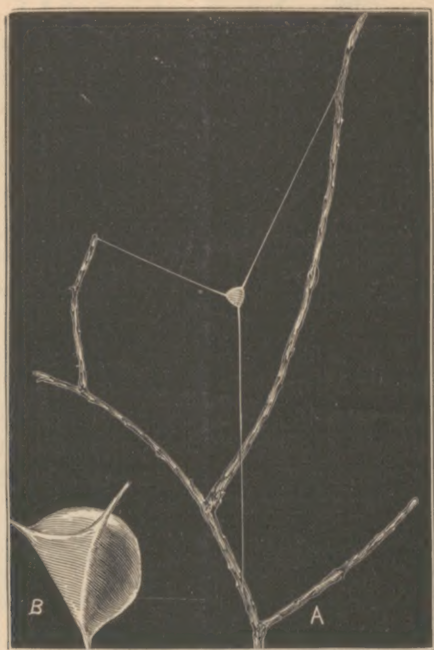

FIG. 4.—SUPPOSED COCOON (EGG-CASE) OF TRIANGLE SPIDER.
A, the cocoon, of natural size, hung by thread-lines between hemlock-twigs; *B*, the cocoon enlarged, seen obliquely, so as to show the triangular base.

The form of these cocoons is quite peculiar: it is that of a little sphere flattened upon one side; at three points the border of this flat side is extended into strong lines, by which the cocoon is suspended between the twigs. Its diameter is about one-tenth of an inch, but the lines are often two or three inches long. The ground-color is usually white; but there are always a few black specks, and sometimes these cover so large a portion of the surface as to make the cocoon appear gray or nearly black.

Besides these more common cocoons, the hemlock-twigs sometimes bear others of about the same size, but pear-shaped, and hanging by the smaller end upon a single short line. To identify these, the spiders should be taken in September, and kept in captivity upon hemlock-branches, so that they may make their cocoons.

2. How is the Net made?—Like most geometrical spiders (*Epeiridæ*), the *Hyptiotes* prefers to construct her net just before day. She is then less liable to interruption, and the newly-made net is best adapted for use in taking the builder's breakfast. To these early habits on the part of the spider is owing the fact that, although I have kept many of them in the house, I have never yet been so fortunate as to witness the entire process of net-making. Twice I sat up all night, but the spiders must have begun just as I fell asleep shortly before day; and my readers will understand that, in the midst of the fall term, a professor does not often feel able to spend a night in watching spiders.

However, I have twice witnessed the completion of nets, and have seen enough of the process to enable me, aided by what is known of spiders' methods in general, to infer how the net is begun and carried on, and the correctness of the following description may be accepted as at least probable, until disproved by actual observation of the entire process:

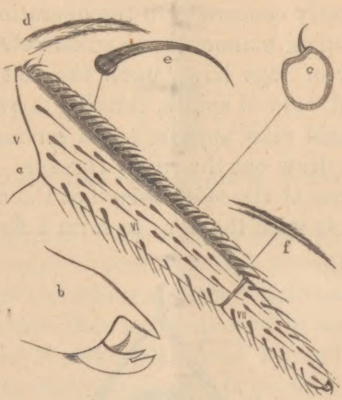

Fig. 5.—*a*, last two segments of the hinder (fourth) leg of a female *Hyptiotes*; *b*, tip of the last segment, showing the claws open; *c*, cross-section of the last segment but one, showing its cavity, in which lie the muscles, and a single curved bristle upon the side, a part of the *calamistrum*; *e*, a similar bristle still more enlarged; *d*, *f*, two feathered bristles from near the joints.

Having first decided upon the general location of her net, the spider probably takes position head downward upon the "leeward" side of a twig or small branch, or upon its top, and then, turning her abdomen outward, expresses from her spinners a drop of gum, which instantly dries so as to form a fine end of a silken thread. This is taken by the wind (and careful experiments have proved that a current of air is absolutely necessary to the extension of the line) and wafted outward, waving from side to side, and usually tending upward from its extreme lightness, until at last it touches some other branch at a greater or less distance from the first. When this stoppage is perceived by the spider, she turns about and pulls in the slack line, until she is sure that the other end is fast. If it yields, she tries

again and again, until successful. If it holds, she attaches her end firmly by pressing her spinners upon the wood, so as to include the line. The first and most important step in the construction of all geometrical nets has now been taken, and the spider can meet with no serious difficulty in completing her task.

But the following steps might be taken in more than one way, and perhaps are so at different times, or by different individuals. And, in view of the risk of making inferences as to the habits of animals, I refrain from the description of what may occur, and simply state that in some way the spider connects with the original horizontal line four others, constituting respectively the base-line (B B) of the net, and the three lower radii (R'' R''' R'''') which are joined to the base-line at F, G, and H. The upper radius (R') is formed from the central part of the original line, and the three others unite with it at A, the apex of the triangular net. (*See* Figs. 1, 8, 9.)

The framework of the net is now ready, and the spider begins to construct the more essential part of its snare.

The organs directly concerned in the operation are the hinder pair of legs and the spinning mammulæ, or spinnerets.

The fourth pair of legs have, upon the last segment but one, a series of strong and curved spines, forming a rake with teeth finely set. When used, this rake appears to be carried backward over the spinnerets, so as to draw out the silken threads.

It seems to represent the *calamistrum* of the other *Ciniflonidæ*, but has no such effect, as with them, as to form a flossy border upon the silken thread.

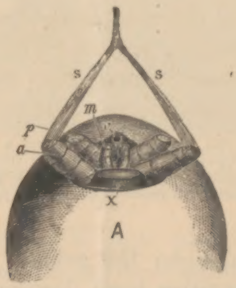

FIG. 6.—VIEW OF THE SPINNING APPARATUS OF *Hyptiotes Americanus*, FROM BELOW AND IN FRONT.

A, the lower surface of the abdomen; *v*, the vent or outlet of the intestine, opening through a papilla; *a*, one of the anterior pair; *p*, one of the posterior pair; *m*, of the middle and smaller pair; *x*, a low oval projection just in front of the spinners, which seems to correspond to the fourth pair in other species; *s s*, the silk from the anterior spinners, uniting to form one line, but capable of drying so as to form the two strands of the double interradial. I do not know from which spinners the various parts of the net are formed.

The *spinning mammulæ*, or *spinnerets*, are represented in Fig. 6. They form a little group upon the lower surface of the abdomen, near its hinder end. In a state of rest, they are closely approximated, but when in use they are more or less widely spread apart like so many fingers or short legs. Indeed, there is reason to regard the spinners as

corresponding in essential structure with the true legs of the spider. They are jointed or articulated, and capable of considerable movement. Their number and form vary with different genera. In our spider there are three pair, anterior (*a*), middle (*m*), and posterior (*p*). The middle pair are smaller, and ordinarily concealed by the others. Behind the spinners is the median papilla through which opens the vent (*v*). In front of them is a low, broad, oval-topped papilla (*x*), in which I find no trace of division into two, nor any silk-tubes. It probably represents the fourth pair of spinners, which exist in the other *Ciniflonidæ*.

The tips of the spinners are provided with many little tubes, having the appearance seen in Fig. 7. Through these is drawn the gum

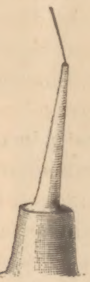

FIG. 7.—A SINGLE SILK-TUBE FROM THE END OF AN ANTERIOR SPINNER.

secreted by the silk-glands within the abdomen, and all the strands from a single spinner may combine to form a single thread.

It is probable that the different pairs of spinners are supplied from different glands, and that they are employed in making different parts of the net. With the *Nephila plumipes*,[1] I found that from one pair came only white silk, while another pair produced only yellow. By separating these with pins, soon after leaving the body, and attaching

[1] For an account of this species, and of the *Epeira riparia*, see the following papers:

"On the *Nephila plumipes*, or Silk-Spider of South Carolina" ("Proceedings of the American Academy of Arts and Sciences," November, 1865).

"On the *Nephila plumipes*" ("Proceedings of the Boston Society of Natural History," October 4, 1865).

"On the Silk-Spider of South Carolina; Four Lectures before the Lowell Institute, March, 1866" (unpublished).

"How my New Acquaintances spin" (*Atlantic Monthly*, August, 1866).

"Memoirs of a Cripple" (*Our Young Folks*, September, 1866).

"Researches and Experiments upon Silk from Spiders" (Termeyer, 1810–1820?) edited by B. G. W., and published in the "Proceedings of the Essex Institute," Salem, Mass., July 6, 1874.

"Two Hundred Thousand Spiders" (*Harper's Magazine*, March, 1867).

"The Practical View of Spider's Silk" (*The Galaxy*, July, 1869).

"The Habits and Parasites of *Epeira riparia*" ("Proceedings of the American Association for the Advancement of Science," 1873).

'The Nets of *Epeira*, *Nephila*, and *Hyptiotes* (*Mithras*)." (Ibid.)

them to a cylinder, the two colors were wound separately from the living spider. Thus far, however, I have failed to ascertain their distinction with this species. So my figure and description may not be correct in assigning to the anterior pair the duty of supplying the interradial lines.[1] However, it seems probable that the process is as follows: One or more pairs of the spinners are first pressed together and then separated. This draws out the silk as a band connecting their tips. By keeping them apart, and repeatedly carrying the *calamistrum* backward across their tips, the lines from each of the two mammulæ in one pair are kept separate until thoroughly dried. When the line is completed and drawn taut they remain distinct, but very near together.

We are now ready to observe the way in which the spider employs the organs above described. Let us suppose that the framework of the net is completed, and that the first or longest interradial line (Fig. 8, I') has also been made. Instead of beginning the second interradial at S'''', she begins at 4; and instead of climbing up the interradial or the strong and convenient base-line (B B), she runs to a point (2) near the apex, crosses the two intermediate radii, and passes along the upper radius to the attachment of the first interradial (S'). On reaching this, she turns and moves for about her own length toward the apex. Contrary to the usual habit of spiders, during this roundabout passage from 1 to 4 she spins no thread. She now spreads her spinners a little, and presses them upon the radius, keeping them so while she advances again about her own length. This forms the attachment of the second interradial. The spider then lets her abdomen fall somewhat, supporting her body and advancing upon the line by means of her first, second, and third pairs of legs. The fourth pair are applied together to the spinners with great rapidity, at least five times in a second or three hundred times in a minute, and in so doing they draw out a *double line*.[2]

The spider moves slowly along the radius until she reaches a point (5) where she can step across to the next radius (R''). While so doing, she ceases to draw out the double line, and carefully keeps it from

[1] From a notice in the *American Naturalist* for February, 1875 (page 125), it appears that Mr. A. J. M. Underhill has lately published, in *Science Gossip*, some observations upon the employment of the different pairs of spinners. He assigns to the third (middle?) pair the production of a line which is either viscid or curled.

[2] I must here admit an error in a previously-published account of the net ("Proceedings of the American Association for the Advancement of Science," 1873, pages 264–274). The interradial lines were there described as *viscid*. The fact is, that I had never thought it necessary to examine them under the microscope, since the interradial lines of all the *Epeiridæ* are viscid; that is, consist of a slender axis enveloped by a viscid coating, which, soon after the net is completed, runs spontaneously into minute globules. Finding that the interradial lines of the "triangle-spider" were elastic, and that they readily adhered to the prey, or to any other body, I not unnaturally, but most unscientifically, drew the inference that with this spider the lines were likewise viscid. During the summer of 1874, while examining the manner of attachment of these lines to the radii, I saw that the interradial lines were neither viscid, like those of the *Epeiridæ*, nor provided

contact with either of the radii. She then retraces her steps along the second radius to a point (6) nearly under that whence she started. The double line has shortened itself considerably ; any slack she draws in, and then, turning about, with her head toward the apex, she makes a second attachment with her spinners close pressed against the radius.

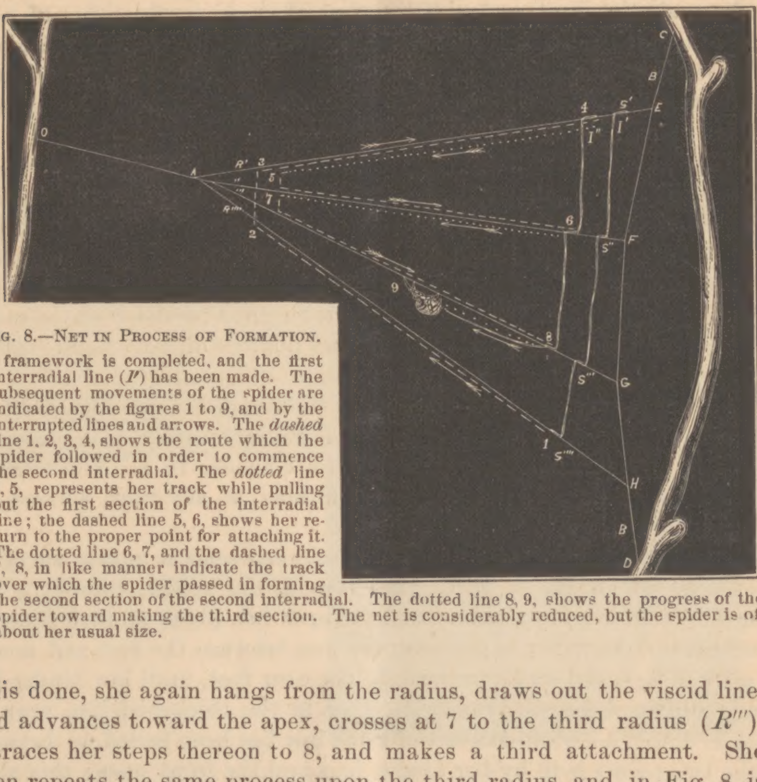

FIG. 8.—NET IN PROCESS OF FORMATION.

The framework is completed, and the first interradial line (I') has been made. The subsequent movements of the spider are indicated by the figures 1 to 9, and by the interrupted lines and arrows. The *dashed* line 1, 2, 3, 4, shows the route which the spider followed in order to commence the second interradial. The *dotted* line 4, 5, represents her track while pulling out the first section of the interradial line ; the dashed line 5, 6, shows her return to the proper point for attaching it. The dotted line 6, 7, and the dashed line 7, 8, in like manner indicate the track over which the spider passed in forming the second section of the second interradial. The dotted line 8, 9, shows the progress of the spider toward making the third section. The net is considerably reduced, but the spider is of about her usual size.

This done, she again hangs from the radius, draws out the viscid line, and advances toward the apex, crosses at 7 to the third radius (R'''), retraces her steps thereon to 8, and makes a third attachment. She then repeats the same process upon the third radius, and, in Fig. 8, is represented as having finished about one-half of the line.

It must be borne in mind that the spider is not reduced, like the net ; and also that, to save space, the interradial spaces are not so wide

with a fine floss, as with the other *Ciniflonidæ*, but simply *double lines*, the two strands being from $\frac{1}{800}$ to $\frac{1}{2000}$ of an inch apart.

My error exemplifies the utter insufficiency of property and function as a guide to structure, and enforces the general principle in natural history, that nothing should be stated as a *fact* that has not been verified by *observation*. It was his avoidance of this kind of error which rendered the work of the late Prof. Jeffries Wyman so remarkably trustworthy.

Since the foregoing was in type, I have learned from Mr. J. H. Emerton, of Salem, that some of his observations upon the structure and economy of this spider do not accord with those here recorded. It is to be hoped that the views of this accomplished and enthusiastic arachnologist will be incorporated with the new edition of Hentz's papers, which he is preparing for publication by the Boston Society of Natural History.

as in Nature. The remaining interradials are formed in like manner, their number varying from six to fifteen.

It will be seen that, by first making the double line nearest the base-line, and afterward the others in their order, the spider avails herself of the fact that a less and less distance is to be successively gone over before crossing from one radius to the next; whereas, if she made the shortest double line first, then she would either be liable to entangle the other if she crossed at the apex, or, if she went around by the base-line, the distances to be gone over would constantly decrease *inversely* to the lengths of the double lines themselves, causing either waste or entanglement.

It is not yet certain just how long a time is required for making the entire net; but, in one case, the spinning of the five lesser viscid lines occupied the spider ten minutes; the other and longer ones may have taken twice as long; and, as the return-movements are rapidly executed, we may say that, for at least half an hour, the little spider is moving her hinder legs together and with great precision at the rate of 300 times per minute, making the total number of movements 9,000!

How IS THE NET USED?—If the making of the net is peculiar, its use is even more remarkable; and here, fortunately, few points remain to be cleared up; for the spider's response to a disturbance of her net by a fly is so prompt that one may, at any time, witness the operation.

At the close of what to the observer seems a pretty energetic exercise of all her faculties and powers, the spider, without a moment's rest, goes to a point upon the apex-line about an inch from the origin (*O*), and, firmly grasping the line between the first and second pairs of feet, she walks backward, foot over foot, until her hinder feet are caught in the attachment itself, or in the thickened line near it; in so doing, a certain amount of slack-line has been furled up between the two points held by her hinder legs and the front ones; this slack is kept away from her body by means of the third pair, which are shorter than the others. Evidently the effect of the above operation is to draw the net toward the apex, the two middle radii being most affected, and with them the central portion of the base-line to which they are attached; and the whole net assumes the appearance shown in Fig. 1.

It is now upon the stretch; and the degree of tension is very considerable, judging from the violence of the snap when it is let go; the exact amount has not yet been measured, but, when it is borne in mind that the spider remains motionless for hours, perhaps for days, constantly holding her net ready for action, we may conclude that, as is the case with other insects, her powers and her endurance are, in proportion to her size, quite beyond what we are familiar with among the higher animals. But our spider's ability to keep still is fully

equaled by her capacity for action when the moment arrives; and yet she is by no means hasty; as a general thing (the exceptions being due perhaps to hunger, or inexperience), the vibration of the net by an insect must be pretty decided, and at least once repeated, before the spider feels justified in springing her trap; and when, as may sometimes happen naturally, but more often through experiment, a large or fierce insect is put into the net, nothing will induce the spider to budge; she will suffer her net to be wholly destroyed rather than expose herself or her reputation (?) to a doubtful encounter. Let us suppose, however, that a common fly, or a gnat, or a moth, has

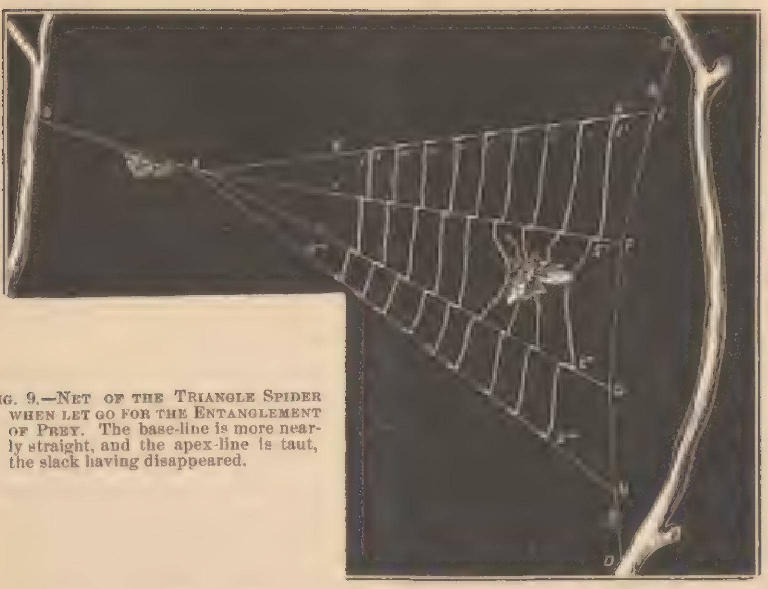

FIG. 9.—NET OF THE TRIANGLE SPIDER WHEN LET GO FOR THE ENTANGLEMENT OF PREY. The base-line is more nearly straight, and the apex-line is taut, the slack having disappeared.

struck the net in passing—it may have touched a single double line—but this adheres with the greatest tenacity, and is so elastic as to yield without breaking, so that each struggle involves the victim still more, and may even bring it into contact with the next interradial. As soon as the violence and repetition of the vibration indicate that an insect is really entangled, the spider awakes from her apparent apathy; she lets go with her hinder feet; the net, released from its tension, flies forward, and at the same time flaps from side to side.

The comparative inertia of the fly causes the two or three double lines next to it on the side toward the apex to be, as it were, propelled against it, and the entanglement is aided by the sidewise flapping already mentioned; as may be imagined, all this is pretty apt to involve the fly beyond the possibility of escape; but, if the spider does not feel certain of this, she creeps backward again, foot over foot, as

before, and again springs her net; and this I have seen repeated in quick succession *six times* before the spider has ventured to make a personal approach. She has already been carried a little way toward her prey by the snapping of the net, for she always retains her hold of the apex-line by her first two pairs of feet, and the third pair serves to steady her as the slack-line slips between them. Advancing now to the junction, she seems to ascertain the exact location of the fly by pulling upon the radii.[1] Having decided, she runs along the chosen radius, and sometimes, when the prey is small, or hopelessly entangled, contents herself with pulling it up by means of the lines about it, and carries it to her accustomed station to be eaten at her leisure.

But more often she adopts a method of securing her prey which, so far as I know, is peculiar to this genus, and involves the destruction of her entire net.

Before reaching the apex (*A*), she cuts with her jaws the apex-line, but, as she keeps constant hold in front of the cut by her first and second pairs of feet, and has a communication in the rear through the line which most spiders always attach to a point behind them, she does not fall, neither is the net loosened beyond a certain limit; it usually seems to recoil about an inch; this recoil tends to entangle the prey like the original snaps of the net. The spider again advances, gathers the radii together and cuts them all, still keeping the line out behind; again the net recoils and collapses. Again she advances and cuts the radii; the net is now hardly distinguishable as such, and is falling together about the devoted fly; the spider now spreads her legs, gathers the net between them and flings it like a blanket over her victim; struggles are now in vain; but, "to make assurance doubly sure," the spider grasps the mass, transfers it to her third pair, and with them turns it over and over as a ball, hanging the while by her front legs, and, with the hinder pair used now *alternately*, drawing out from the expanded spinners broad sheets of silk which, relatively to the power of the fly, are like steel bands upon a man. Having in this way reduced the prey to a rounded ball, in which its limbs are hardly distinguishable, the spider takes it in her jaws and mounts to her place.

A single fly of ordinary size seems to occupy a whole day in the eating. When finished, the remains are cast down as a pellet, so perfectly deprived of moisture, that it is probable that this species, like the *Nephila*, and perhaps all *Epeiridæ*, sucks out the gum of its old net and reëlaborates it in her organs for use in making a new one.

Whether this peculiar economy is practised or not, it is certain that the *Hyptiotes* often sacrifices its whole net in the capture of a single fly; and that the making of this net involves an amount of labor and of skill which one would think not lightly to be thrown away.

[1] As with the *Nephila*, and perhaps all other geometrical spiders, this species seems to perceive *light* only, and not to see objects distinctly.

THE RELATIONS OF HYPTIOTES.—In these days of evolution, we can hardly wait to learn what an animal does in the present, before we inquire what its ancestors were, and how it came to be what it is.

Ideally, one may at once draw a curious comparison between *Hyptiotes* and two other spiders already referred to in this article, namely, the *Epeira* and the *Nephila* ; for the net of the former is a complete circle, that of the latter is a circle lacking its upper sextant, while the net of *Hyptiotes* is just about the sextant or sixth of a circle. To use a more homely comparison, the net of *Epeira* is an entire pie, that of *Nephila* is a pie with a piece cut out, while that of *Hyptiotes* represents the missing piece. In algebraic language, *Nephila* + *Hyptiotes* = *Epeira*.

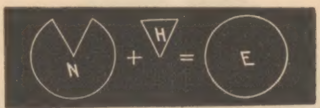

FIG. 10.—DIAGRAM REPRESENTING THE FORMS OF NETS OF NEPHILA (N), HYPTIOTES (H), AND EPEIRA (E).

But, while the above comparison enables us to contrast the nets of the three genera, it by no means satisfies the inquirer as to the derivation of the forms in question. To answer this in full would require a more complete knowledge than we now possess, and would involve a discussion too technical for these pages; but there are a few considerations easily presented, which indicate that the gaps between the forms are not so great as at first appears.

1. The net of the ordinary geometrical spiders, like that of *Epeira riparia*, consists of a continuous spiral viscid line laid upon radii, while that of *Nephila* presents a larger number of radii upon which is laid a *looped* viscid line, which does not extend across that part of the circle just above the centre. But in several nets, otherwise of usual geometrical character, I have found one or the other side, but usually the bottom, extended considerably by the addition of several *looped* lines, like those made by *Nephila* ; so that we may imagine that *Nephila* has merely perpetuated and intensified into constancy a method of net-making which was occasionally employed by the form from which it and the common *Epeira* are both descended.

2. At least one species of *Epeira* (the *E. calophylla* of Great Britain, described by Mr. Blackwall) constructs a net of looped lines, like that of *Nephila*, but the loops terminate on both sides of a *single* radius, which serves as a line of communication between the centre of the net and a cell under a neighboring leaf. Now, if we imagine the net to be reduced from many radii to four, then the single divergent radius of *E. calophylla* would represent the apex-line of *Hyptiotes*

3. Many and perhaps all geometrical spiders are accustomed to shake their nets violently when touched, and sometimes to seize

several radii in their claws, and draw them up and let them go suddenly; such a habit may have been the foundation of the remarkable device adopted by *Hyptiotes*.

One further inquiry is suggested by the fact that the net consists invariably of *four radii*. Whatever other variations there may be in the spider's work, as to the size and proportions of the net, and the number of interradial lines, the *number of radii is constant*. In more than a hundred nets, I have found the number to be *four*, never more nor less. Now, this seems to offer a confirmation of the common idea that spiders' webs, like bees' cells, are constructed with absolute accuracy, and are models for poor humanity.

FIG. 11.—NET OF *Nephila plumipes*, made in a wire frame, and photographed upon wood; reduced. In nature, the free radii, as above described, occupy about $\frac{1}{8}$ of the area; but the web of which a figure is given was made upon a frame, the limits of which seem to have interfered with the extension of the loops above the level of the centre of radiation.

But Prof. Jeffries Wyman has shown that *no such exactitude prevails with the cell of the honey-bee;* for, while the average diameter of a large number of worker cells is about one-fifth of an inch, yet the difference between two cells has been found to be one-fortieth of an inch, and the aggregate diameter of ten cells may differ from that of another set of ten cells one-fifth of an inch, or the diameter of a single cell. The width of the sides varies to an appreciable extent; likewise the angles between the sides; a fourth face is often introduced into the base, and the rows of cells may be greatly out of line; in short, while it is probable that the bees work with reference to an ideal or type implanted in them, Prof. Wyman is inclined to *doubt whether a type-cell is ever really made.*[1]

The reader will now be prepared to hear that, after careful examination of large numbers of nets of many different spiders, I have yet to find one in which the irregularities could not be detected by the

[1] "On the Cells of the Honey-bee" ("Proceedings of the American Academy of Arts and Sciences," January 9, 1866, pp. 68–82; 6 figures).

eye. The radii and viscid lines differ in number (the number of radii being constant only in *Hyptiotes*). Their distance apart varies greatly, as might be expected from the fact that spiders make their measurements hastily, and with no apparent attempt at precision; in fact, the irregularities are such as would disgrace any human artificer. We must conclude that the popular belief upon the subject is based upon very superficial observation, and that it had its rise in the old theological idea that because the Creator is perfect, so must be the performances of all his creatures, excepting the one example of total depravity—man.

But let this not trouble us. Like the orthodox interpretation of Scripture, so the orthodox interpretation of Nature may be far out of the way; and the readiness with which the world has accepted new views, when their correctness is beyond controversy, and yet kept its faith in the power, the wisdom, and the goodness of God, shows the truth of the following aphorism: "It is important not to confound the fundamental order of Nature, which is indeed immutable, with the ideas, more or less complete, which we entertain at a given time, respecting the manner in which that order is manifested."